

Report for 2002PA3B: Water Reuse: Using Crumb Rubber for Wastewater Filtration

- Other Publications:

- Xie, Y.F., Y. Zhou, B. Killian, S.Y. Hsiung, 2002, "An Innovative Filter Medium for Wastewater Filtration", AEESP/AAEE Conference 2002, Toronto, Canada,(Poster Presentation).
- Hsiung, S.Y., and Y.F. Xie, 2003, Filtration Using a Crumb Rubber Media, the 2003 Penn State Environmental Chemistry Symposium, University Park, PA, (Poster Presentation).
- Hsiung, S.Y., and Y.F. Xie, 2003, Waste Tires for Wastewater Water Treatment, Innovature 2003, Hershey, PA, (Poster Presentation).

Report Follows:

Problems and Research Objectives

Pennsylvania has been in drought conditions in five of the last seven years. In February 2002, 62 of Pennsylvania's 67 counties were under a drought declaration. 24 counties were under drought emergency, 7 under drought warning, and 31 under drought watch. Using reclaimed wastewater for beneficial application is the key for solving the water shortage problems in Pennsylvania. Wastewater filtration is a critical treatment process for wastewater reclamation. An innovative filter medium consisting of crumb rubber from recycled tires was developed in the Environmental Engineering Laboratories at Penn State Harrisburg. In an earlier study we found that the filter performance of a crumb rubber filter was comparable with that of a conventional dual-media sand/anthracite filter using synthetic wastewater.

The objective of the proposed study is to optimize the crumb rubber media filter for wastewater filtration and conduct a side-by-side comparison between the crumb rubber filter and the conventional sand/anthracite filter. The feasibility of wastewater filtration for wastewater reuse will be evaluated as well.

Methodology

Phase I. Effects of the size and depth of crumb rubber

In this phase of the study, synthetic wastewater, prepared with mixed liquor samples from a local wastewater treatment plant, was used to evaluate the filter performance, including filtration rate, headloss, SS removal, and filter run time. Two 4-inch pilot filters, crumb rubber and dual-media sand anthracite, were used. The crumb rubber with various sizes was obtained from a local scrap tire recycle plant. Specific crumb rubber sizes were selected using sieves in laboratory. The objective of this phase of the study is to identify proper crumb rubber size and filter bed depth.

Phase II. Field Studies

The field study was used to verify the application of crumb rubber filters in wastewater filtration. A field study pilot unit was constructed under the project. Three 6-inch diameter clear PVC columns were used. Headloss indicators were constructed with glass tubes. The proper crumb rubber size and bed depth identified under Phase I were used in this study.

The Penn State University Park Wastewater Treatment Plant was used as the field test site. The plant uses primary sedimentation, trickling filter, activated sludge, final clarification, and chlorination. Currently, the wastewater effluent is discharged on two spray fields. The influent and effluent samples were collected for analysis of suspended solids, BOD, and phosphorus. Paired samples were also collected for a pilot scale dual-media sand/anthracite filter.

The field study provided side-by-side comparisons between the crumb rubber filter and dual-media sand/anthracite filter. The final comparison was made based on the filter effluent quality and filter water production.

Principal Findings and Significance

1. Both the sand/anthracite and crumb rubber filters were effective at reducing effluent suspended solids from 6-16 mg/L down to <5 mg/L, and reducing turbidity from 4-10 NTU to <4 NTU. For particles between 3 to 11 μm , a 90% removal was achieved in both filters.
2. The crumb rubber filter exhibited much less head losses than the sand/anthracite filter when operated at the same filtration rates. The crumb rubber filter can be operated at higher filtration rates than the sand/anthracite filter or anthracite filter.
3. The combination of higher filtration rates, lower head losses, and lower backwash water rates for the crumb rubber filter indicates that the crumb rubber filter can have significant higher water production rates than sand/anthracite filters.
4. The porosity of the crumb rubber medium was approximately 70% in comparison to sand medium at 45% and anthracite medium at 58%. In comparison to sand and anthracite, a greater depth filtration was observed in the crumb rubber filter, especially in the late filtration stage.
5. Various design, filtration, and backwash criteria were developed for the crumb rubber filter. For wastewater filtration, the authors suggest a filter medium depth of 36 inches and crumb rubber size at 1.2 to 2.0 mm. A filtration rate at 10 gpm/ft^2 and a backwash water flow rate at 12 gpm/ft^2 are also suggested.
6. Both crumb rubber filter and sand/anthracite filter gave a poor phosphorus removal. Further study should be conducted using various coagulant types (e.g., alum and ferric salts) and doses.

Student Supported

Three students were supported under the projects:

1. Shih-Yun Hsiung (MS), in Environmental Engineering at Penn State University Park
2. Mathieu Combescure (BS), French visiting student in Department of Civil and Environmental Engineering, Penn State University Park
3. You Zhou (ME), in Environmental Pollution Control at Penn State Harrisburg